Check List the journal of biodiversity data

NOTES ON GEOGRAPHIC DISTRIBUTION

Check List 14 (2): 303–308
https://doi.org/10.15560/14.2.303

PENSOFT

Advertisement call and new distribution records from Brazil of *Teratohyla midas* (Lynch & Duellman, 1973) (Anura, Centrolenidae)

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Abstract

Data on the distribution and calls of glassfrogs are important for taxonomic and conservation purposes. Herein, we describe the acoustic parameters of *Teratohyla midas* (Anura, Centrolenidae), with notes on distribution in the Brazilian states of Acre, Amapá, Amazonas, and Pará. The typical advertisement call of *T. midas* consists of a single pulsed note, with 3 pulses emitted in a very short emission. The advertisement calls of *T. midas* from Ecuador and French Guiana are distinct from those reported here.

Key words

Glassfrogs, acoustic parameters, Amazon biome.

Academic editor: Raul Fernandes Dantas Sales | Received 21 October 2017 | Accepted 18 January 2018 | Published 9 March 2018

Citation: Araújo KC, Pansonato A, Oliveira RH, Morais DH, Carvalho VT, Ávila RW (2018) Advertisement call and new distribution records from Brazil of *Teratohyla midas* (Lynch & Duellman, 1973) (Anura, Centrolenidae). Check List 14 (2): 303–308. https://doi.org/10.15560/14.2.303

Introduction

Glassfrogs of the family Centrolenidae Taylor, 1951 currently comprises 151 species, distributed in 12 genera (Frost et al. 2017). They are widely distributed in South and Central America (Cisneros-Heredia and Mcdiarmid 2007), although only the genera *Teratohyla*, *Vitreorana*, and *Hyalinobatrachium* have been recorded in Brazil (Segalla et al. 2016). Thirteen species are known to occur in Brazil: *Hyalinobatrachium cappellei* (Van Lidth de Jeude, 1904), *H. carlesvilai* (Castroviejo-Fisher et al., 2009), *H. iaspidiense* (Ayarzagüena, 1992), *H. mondolfi* (Señaris & Ayarzagüena, 2001), *H. munozorum* (Lynch & Duellman, 1973), *Teratohyla adenocheira* (Harvey & Noonan, 2005), *T. midas* (Lynch & Duellman, 1973), *Vitreorana baliomma* (Pontes et al., 2014), *V. eurygnatha* (Lutz, 1925), *V. franciscana* (Santana et al., 2015), *V. parvula* (Boulenger, 1895), *V. ritae* (Lutz & Kloss, 1952) and *V. uranoscopa* (Müller, 1924) (Segalla et al. 2016).

Data on the distribution and calls of glassfrogs are important for taxonomic and conservation purposes (Castroviejo-Fisher et al. 2011). However, advertisement calls have been described for fewer than 25% of species of glassfrog (Vargas-Salinas et al. 2015), and the geographic distribution of many species is poorly documented. *Teratohyla midas* is distributed in Brazil, Colombia, Ecuador,

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Figure 1. Live specimen of *Teratohyla midas* from Primavera, Pará, Brazil (voucher specimen UFMT 11543). Collection date: 18 December 2010. Elevation: 72 m. Snout–vent length: 18.35 mm.

French Guyana, and Peru (Lynch and Duellman 1973, Marty and Gaucher 1999, Rodriguez et al. 2004, Cisneros-Heredia and McDiarmid 2005, Lynch 2005, Kok and Castroviejo-Fisher 2008, May et al. 2008, França and Venâncio 2010, Catenazzi et al. 2013, Malambo et al. 2013, Warren-Thomas et al. 2013). In Brazil, *T. midas* is recorded mainly in the Amazon region (Melo-Sampaio and Oliveira 2013, Melo-Sampaio and Souza 2015); moreover, it was recorded in the transitional area between Amazon and Cerrado biome, in Maranhão state (Pontes and Mattedi 2013).

The most conspicuous morphological characteristics of *T. midas* described by Lynch and Duellman (1973) are not sufficient to distinguish centrolenid species from one another (Cisneros-Heredia and McDiarmid 2007, Guayasamin et al. 2009). Therefore, we highlight the importance of acoustic parameters to distinguish the Centrolenidae species, because some morphological characters are ambiguous with other centrolenids.

Analysis of acoustic parameters of *T. midas* have not been exhaustively studied. Advertisement calls of *T. midas* from French Guyana (Marty and Gaucher 1999) and Ecuador (Read 2000) were presented with oscillogram and spectrogram (Kok and Castroviejo-Fisher 2008). Herein we describe the acoustic parameters of *T. midas* with notes on its distribution in the Brazilian states of Acre, Amapá, Amazonas, and Pará.

Methods

The new records of *Teratohyla midas* from the states of Acre, Amapá, and Amazonas were obtained from specimens preserved in the collection of the Instituto Nacional de Pesquisas da Amazônia (INPA; Manaus, Amazonas, Brazil).

Additionally, on December 18, 2010, 2 specimens of *T. midas* were captured on in municipality of Primavera, Pará state, Brazil. A permit to collect voucher species was issued by the Secretaria de Estado do Meio Ambiente e Recursos Naturais (SEMA/PA AU No. 1080/2010. Collected specimens were photographed (Fig. 1), euthanized, preserved in 70% ethanol, and deposited in the Coleção Zoológica de Vertebrados, Universidade Federal de Mato Grosso (UFMT; Cuiabá, Mato Grosso, Brazil).

Advertisement calls of individual of *T. midas* described here were recorded by Robson W. Ávila with a professional digital recorder Marantz PMD 660 with an external directional microphone Yoga EM-9600 in municipality of Primavera, Pará state, Brazil. Digital recordings were sampled at 44.1 kHz, with 16 bits resolution and saved in uncompressed wave files. Recordings were analyzed on a personal computer using Raven Pro 1.3 (Bioacoustic Research Program 2012), with the following settings: Hamming window function; Hann window type; DFT size 256-point samples; brightness

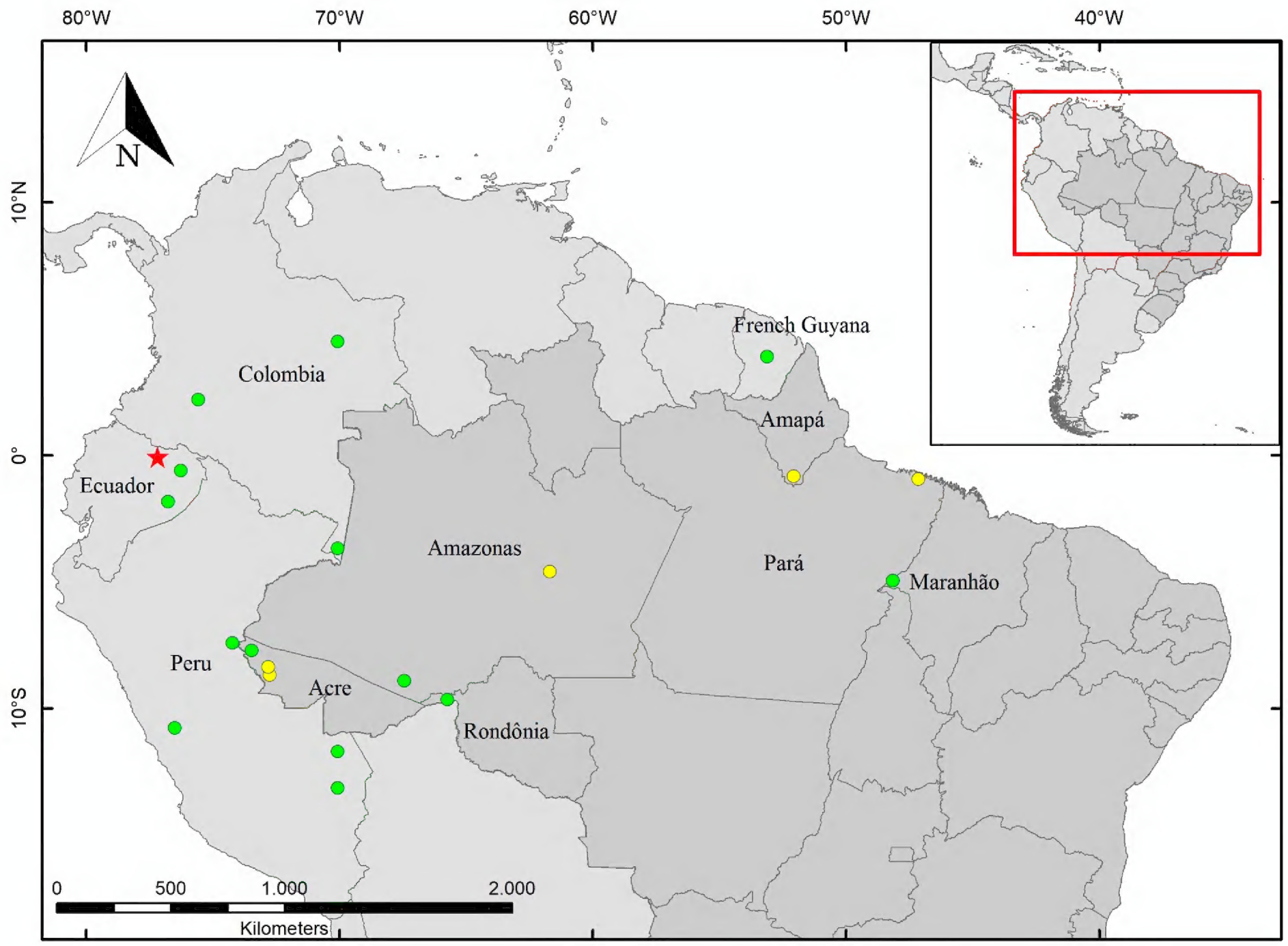

Figure 3. Distribution map of *Teratohyla midas*. Red star: Type locality (Santa Cecilia, Province of Napo, Ecuador) (Lynch and Duellman 1973). Green circles: literature records of species from Colombia, Ecuador, French Guyana, Peru and Brazil (Acre, Amazonas, Maranhão, and Rondônia states (Cisneros-Heredia and McDiarmid 2005, Kok and Castroviejo-Fisher 2008, May et al. 2008, França and Venâncio 2010, Catenazzi et al. 2013, Malambo et al. 2013, Melo-Sampaio and Oliveira 2013, Warren-Thomas et al. 2013, Pontes and Mattedi 2013, Rodríguez et al. 2014, Twomey et al. 2014, Melo-Sampaio and Souza 2015). Yellow circles: new records of *T. midas* for Brazil (Acre, Amapá, Amazonas, and Pará states).

= 74%; contrast = 76%; time grid overlap = 50%. To produce audiospectrograms and waveforms, we used the R package "Seewave" (Sueur et al. 2008) and tuneR (Ligges et al. 2014), with the following settings: FFT size of 512 points, Hanning window, and 90% of overlap. The following temporal parameters were measured manually from the waveform: duration of note, pulse, inter-note and inter-pulse intervals; number of pulses per note. Note repetition rates were calculated per minute. The dominant frequency was obtained from spectrograms. Terminology for acoustic parameters follows Köhler et al. (2017). Calls are archived in the Banco de Registros Bioacústicos, housed at the Laboratório de Herpetologia do Instituto de Biociências da Universidade Federal de Mato Grosso (LH; Cuiabá, Mato Grosso, Brazil), LH 403.

Results

New records (Fig. 2). Brazil: Pará: municipality of Primavera (00°56′25″ S, 047°06′59″ W, WGS84 datum, 72 m elev.), 18 December 2010, Robson W. Ávila (UFMT 11543, 11544). Amapá: municipality of Vitória do Jari (00°34′37″ S, 052°04′40″ W, WGS84 datum, 51 m elev.), 20 December 2010, Vinicius T. Carvalho (INPA-H 30632, 30633, 30634). Acre: municipality of Porto Walter (08°40′39″ S, 072°46′04″ W, WGS84 datum, 215 m elev.), 11 October 2010, Vinicius T. Carvalho (INPA-H 4647, 4758, 4766, 4767). Acre: municipality of Porto Walter (08°22′50″ S, 072°49′02″ W, WGS84 datum, 229 m elev.), 12 October 2010, Vinicius T. Carvalho (INPA-H 2591, 2592 INPA-H 2591, 2592). Amazonas: municipality of Beruri (04°35′51″ S, 061°53′30″ W, WGS84 datum, 59 m elev.), 20 November 2010, Vinicius T. Carvalho (INPA-H 11531).

Identification. Our specimens match the descriptions of *T. midas* by Lynch and Duellman (1973) and Guayasamin et al. (2009). This species is morphologically differentiated from another centrolenids by having liver covered by a transparent hepatic peritoneum, digestive tract white, ventral parietal peritoneum white anteriorly and transparent posteriorly, prepollical spine not protruding and the humeral spines lacking (Guayasamin et al. 2009).

The advertisement call of *T. midas* (Fig. 3) consists of a single pulsed note, with 3 pulses in a very short emission (Table 1). Series duration varies from 0.7 to 61.8 s

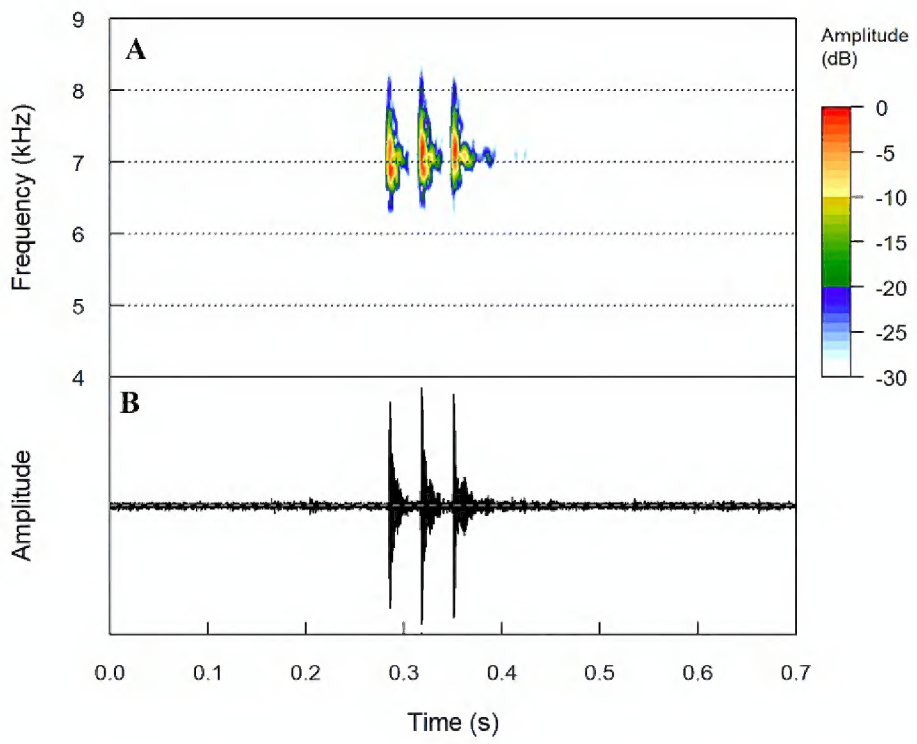

Figure 2. Oscillogram (**A**) and audiospectrogram (**B**) of a single pulsed note of Teratohyla midas, with 3 non-concatenated pulses (voucher record LH 403, from specimen UFMT 11543, recorded on 18 December 2010, 20:20 h, air temperature 24.5ºC, municipality of Primavera, Pará, Brazil).

(mean 13.2 ± 15.5 SD). Duration of each note (or call) varies from 0.087 to 0.1 s (mean 0.092 ± 0.004 SD), internote interval from 9.3 to 25.2 s (mean 13.3 ± 3.9 SD), and the rate of notes per minute from 2.4 to 6.4 (mean 5 ± 1.1 SD). Duration of each pulse varies from 10 to 24 ms (mean 15 ± 2.7 SD). Mean frequency band ranges from 5843.3 Hz (± 182.4 SD) to 8718.8 Hz (± 124.54 SD). Dominant frequency varies from 6837.5 to 7125 Hz (mean 7017.8 ± 91.8 SD).

Discussion

Currently, new centrolenids species are discovered almost yearly (e.g. Harvey and Noonan 2005, Cisneros-Heredia and McDiarmid 2007, Castroviejo-Fisher et al. 2009, Santana et al. 2015) and most of morphological characters are ambiguous in this family (Guayasamin et al. 2009). The white/transparent covering of the liver by the parietal peritoneum is shared by *T. midas* and *T. spinosa* (Taylor, 1949) and hepatic peritoneum and white digestive tract are present in 3 species (*T. amelie* Cisneros-Heredia & Meza-Ramos, 2007, *T. midas* and *T. pulverata* Peters, 1873; Guayasamin et al. 2009). *Teratohyla adenocheira* and *T. midas* are sister species (Castroviejo-Fisher 2014), but the first one has dermal glands along its fingers and toes, the first toe noticeably much longer than other toes, and in preservative, the dorsum is light gray with white markings (Harvey and Noonan, 2005).

The advertisement calls of *T. midas* from Ecuador and French Guiana are distinct from those reported here. Calls from Ecuador presented 4 pulses/call, while in French Guiana and Brazil, they are composed of 3 pulses/call. However, the third pulse has a longer duration in the French Guyana population (Kok and Castroviejo-Fisher 2008) than the Brazilian specimen (this study).

Our record of *T. midas* from the municipality of Primavera was the first for Pará state. This new record extends the geographic distribution of *T. midas* by approximately 900 km southeast from French Guyana (Kok and Castroviejo-Fisher 2008) and 500 km north from the nearest reported occurrence in Maranhão state (Pontes and Mattedi 2013). Our new record of *T. midas* from the municipality of Vitória do Jari is approximately 3000 km east from the type locality of the species and is the first record for Amapá state. The nearest reported occurrences are approximately 600 km north (Kok and Castroviejo-Fisher 2008) and 650 km southeast (Pontes and Mattedi 2013). The 2 populations of T. midas in municipality of Porto Walter, Acre state are about 200 and 150 km south of previously known occurrences provided by Melo-Sampaio and Souza (2015). Finally, the new record in the municipality of Beruri, Amazonas state, is approximately 900 km north of the nearest reported occurrence in Vista Alegre do Abunã, municipality of Porto Velho, Rondônia state (Melo-Sampaio and Oliveira 2013).

Recent studies have recorded *T. midas* at distinct locations throughout the Amazon biome, in Acre (Melo-Sampaio and Souza 2015), Rondônia (Melo-Sampaio and Oliveira 2013), and Amazonas (França and Venâncio 2010). Studies have also found it in the transitional area between the Amazon and Cerrado in Maranhão (Pontes and Mattedi 2013). There are also records in other countries, such as Colombia (Malambo et al. 2013), Peru (Twomey et al. 2014), and French Guyana (Kok and Castroviejo-Fisher 2008), which emphasizes the importance of herpetological studies in the Amazon region for finding new occurrences of glassfrogs.

Glassfrogs belonging to the tribe Cochranellini present important morphological synapomorphies (Guayasamin et al. 2009, Castroviejo-Fisher 2014). We observed that the acoustic parameters of *T. midas* are distinct from other centrolenids of the same tribe, such as *Vitreorana uranoscopa*, *V. franciscana*, *Cochranella mache* Guayasamin & Bonaccorso, 2004 and *C. nola* Harvey, 1996 (Köhler et al. 2006, Ortega-Andrade and Paucar 2013, Zaracho 2014, Santana et al. 2015). Due to the lack of information, we could not investigate differences in acoustic parameters between *T. midas* and *T. adenocheira*, its sister species.

Our analysis of acoustic parameters and physical structure of *T. midas* calls shows the possibility of a species complex. The advertisement calls could be better to distinguish cryptic species than morphology. Therefore, we suggest that both molecular and bioacoustics studies may provide important data to evaluate the taxonomic status of distinct populations.

Acknowledgements

RWA thanks Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for providing a research fellowship (PQ #303622/2015-6), the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior for a postdoctoral fellowships to AP and DHM (CAPES/PNPD 20132816 and 22005013001P4, respectively) and Secre-

taria de Estado do Meio Ambiente e Recursos Naturais (SEMA) for the collection permit.

Authors' Contributions

KCA and RHO wrote the manuscript with support from AP, DHM and RWZ. VTC and RWA captured and identified the specimens. AP, KCA and RHO described the advertisement call. All authors discussed the results and contributed to the final manuscript.

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